Widely separated binary systems of very low mass stars

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Abstract. In this paper we review some recent detections of wide binary brown dwarf systems and discuss them in the context of the multiplicity properties of very low-mass stars and brown dwarfs.

Key words: binary stars, very low mass stars, brown dwarfs, individual star: DENIS-P J0410-1251, LP 714-37

1. Introduction

Binary systems have been studied for decades to measure accurate stellar masses, and to test evolutionary models and star formation theories. Considerable attention has recently been paid to very low-mass (VLM) binaries in the solar neighborhood (Martín et al. 1999a; Close et al. 2002, 2003; Bouy et al. 2003; Burgasser et al. 2003; Forveille et al. 2005), as well as in nearby young open clusters and associations (Martín et al. 2003; Chauvin et al. 2004).

The properties of VLM binaries are an important constraint for models of star-formation and evolution. It has been debated in the literature whether the properties of VLM binaries and stellar binaries differ, implying different formation mechanisms (Kroupa et al. 2003), or whether the binary properties instead show continuous trends with decreasing primary mass, implying that VLM binaries form through the same processes as stellar binaries (Luhman 2004b). Clearly there is a need for a larger sample of observed VLM binaries, particularly at wide separations where few of them are known. One leading model of brown dwarf (BD) formation is that they form and are ejected in unstable multiple systems within small clusters. Since the ejection models (Reipurth & Clarke 2001; Bate et al. 2002) suggest that the binary BD systems that do exist must be close (separations $\leq$ 10 AU). The detection of wide VLM binary systems has thus become an important test of the ejection models. The first wide binary BDs have been found in young (<10 Myr) associations or clusters (Luhman 2004a; Chauvin et al. 2004). Very recently Phan-Bao et al. (2005) found a 33 AU ultracool binary system, Billères et al. (2005) have also reported a discovery of a 200 AU M8.0+L0 binary, both of them in the field and their detection based on the DENIS survey.

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2. LP 714-37AB: the closest wide binary system of very low mass stars

In Phan-Bao et al. (2005) we reported the discovery of a new wide binary system of very low mass stars with projected separation of 33 AU. The calibration of the PC3 index to spectral type (Martín et al. 1999b) gives spectral types of M5.5 for component A and M7.5 for component B, with an uncertainty of $\pm$0.5 subclass. Figure 1 shows that there is no background star at the position of the system in either the SERC-I image (I band) or the DENIS-I image, and therefore demonstrates that the system LP 714-37 is a physical binary. The properties of this system are given in Table 1.

Using the PC3 index to magnitudes relation given in Crifo et al. (2005) and comparison with the DENIS apparent magnitudes give the distance only at 18 pc for our system, this makes LP 714-37AB the closest wide utracool binary system (separation $>$ 30 AU) in the field up to now. Table 2 lists all known wide ultracool field binary dwarfs.

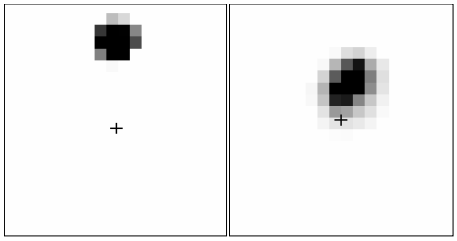

Fig. 1. Archival images of LP 714-37: SERC-I (left, epoch: 1986.940) and DENIS-I (right, epoch: 2000.896). The cross indicates the position of component B at the 2003.915 epoch of the ESO-New Technology Telescope image. Clearly, with the proper motion of the system ($\mu_\alpha = -117$ mas/yr and $\mu_\delta = -382$ mas/yr, Phan-Bao et al. 2003), the SERC-I image would easily separate the two objects if they were not physically associated. The size of each image is $20\times20''$, and North is up and East to the left.

Table 1. Summary of the LP 714-37AB binary system

Stars	PC3	SpT	Mass ($M_\odot$)	Sep. (AU)	dist. (pc)
(1)	(2)	(3)	(4)	(5)	(6)
LP 714-37A	1.32	M5.5	0.11	33.1±4.0	18.1±2.2
LP 714-37B	1.72	M7.5	0.09		

Column 1: NLTT name. *Columns 2* & *3*: The PC3 index and spectral types derived from the (PC3, spectral type) relation of Martín et al. (1999b). *Column 4*: Mass determinations for 1-5 Gyr from the models of Baraffe et al. (1998). *Column 5*: Projected separation. *Column 6*: Spectrophotometric distance.

3. Discussion

Recent surveys demonstrate that VLM binaries with large separations ($>$ 30 AU) are rare in the field, but can be found in young associations and clusters: 2MASS J1101-7732 (240 AU separation, in Chamaeleon I, Luhman 2004a); 2MASS J1207-3932 (55 AU, in TW Hydrae, Chauvin et al. 2004). Phan-Bao et al. (2005) reported the discovery of a 33 AU VLM binary, Martín et al. (2000) found that CFHT-Pl-18 is a 35 AU VLM binary; and very recently, Billères et al. (2005) discovered an M8.5+L0 pair (DENIS-P J055146.0-443412.2) with a physical separation over 200 AU, all of them in the field.

Since ejection models suggest that the binary DB systems that do exist must be close. And therefore the existence of the extremely wide binaries (e.g., 200 AU separation) becomes a very important test of the ejection models (Bate & Bonnell 2005). One should note however that the numerical models to date suffer from small number statistics. One should also note that the relevant quantity is the total mass of the system, and that the apparent binaries could possibly be triple or higher order multiple systems, with a correspondingly higher total mass. This would make them analogs of the GJ1245ABC triple system, which consists of two M5.5 and one ∼M8 dwarfs with separations of 32 and 5 AUs. Triple systems could thus potentially explain the apparent excess of wide VLM binaries, and adaptive optics imaging of LP 714-37, DENIS-P J055146.0-443412.2 would be of obvious interest to clarify its true multiplicity.

Table 2. Widely separated binary systems (separations $>$30 AU) in the field

Stars	Sep. (AU)	SpT_A/SpT_B	Dist. (pc)	Ref.
(1)	(2)	(3)	(4)	(5)
LP 714-37	33	M5.5/M7.5	18	1
CFHT-Pl-18	35	M8.0/M8.0	105	2,3
DENIS-P J0551−4434	200	M8.5/L0.0	100	4

Column 1: Star name. *Columns 2* & *3*: Projected separation and spectral types of components. *Column 4*: Distance estimate. *Column 5*: References: (1) Phan-Bao et al. (2005); (2) Martín et al. (2000); (3) Bouy et al. (2003); (4) Billères et al. (2005).

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